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THE VISUAL CELLS OF LAMPREYS*

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Introduction

The question of the nature of the visual cells of these most primitive of living vertebrates has been controversial for decades. It is especially in need of a final answer because of its bearing upon the problem of the priority of origin of the rod and cone. The accepted theory in this latter connection, holding that the rod is the primitive visual cell and that the cone is a more complex derivative thereof, was put forward by Max Schultze (1866, 1867) and has served as the basis of Mrs. Ladd-Franklin's "genetic" theory of colour-vision and of Parsons' (1927) analysis of the visual sense into "dyscritic" and "epicritic" components.

Examined critically, Schultze's evidence is seen to be no evidence at all; for he mistakenly believed that not only the lampreys and elasmobranchs, but also the ganoids and primitive teleosts[1] have pure-rod retinae. Again, it is scarcely safe to assume with Schultze that the rod is physiologically the simpler element (and "therefore" the older), in spite of the apparent complexity of colour-vision; for not

* A contribution from the Departments of Zoology of the University of Michigan and the State University of Iowa.

[1] Here Schultze was following Haeckel's belief in the eels as the most primitive teleosts; but the eel has enormous cones (Garten 1907).

only may rod vision be quite as complex, but colour-vision may well have been invented long after the advent of the cone as a distinct, high-threshold, isolated-conduction element.[2]

Heinrich Müller (1856) first noted that in the European River Lamprey, *Lampetra fluviatilis*, the visual cells are of two types, long and short, in equal numbers (see Fig. 1). He termed them both cones, but later examined *Petromyzon marinus* in which he found the short elements predominating, and in a footnote to a paper on quite another subject (1862) he suggested that the short elements might be rods. Schultze (1866) first tentatively, later (1867) with more assurance pronounced the *L. fluviatilis* retina pure-rod. W. Krause (1868) insisted that both rods and cones were present, but failed to make clear which was which. Schultze now (1871*a*) about-faced, and termed *L. fluviatilis* pure-cone; but in the same year (1871*b*) once more returned to the pure-rod concept in a contribution to a reference work, practically the last of his many writings. Langerhans (1873, 1876) described the European Brook Lamprey, *L. planeri*, as having rods and cones, figuring the rod as the long cell and giving it a cylindrical outer segment.

Wilhelm Müller (1874) now gave descriptions of *L. fluviatilis*, *L. planeri*, and *P. marinus*, with figures of the two latter species. His drawing of "*P. marinus*" was certainly based upon an exceptionally large *L. fluviatilis*, however, for the two cell-types are shown in equal numbers as they are in *Lampetra*. Müller saw only conical outer segments and compared the long-cells with the rods of higher forms.

In Krause's later papers (1872, 1876*a*, 1876*b*) the duplex condition is again affirmed, and he definitely sides with Langerhans in identifying the long-cell as the rod.

Kühne (1878*a*, 1878*b*) reported rhodopsin in *L. fluviatilis*, and considered the small amount he found indicative either of a low concentration in all cells or of the presence of many rhodopsin-free elements (cones). From this point on it would seem that none could deny the presence of rods, but Kohl (1892*a*, 1892*b*), who made a maximum of errors in his histological observations, found only cones in *L. planeri*, and thought that the Müller fibres had been mistaken for rods by others. Only Kohl has claimed to find "vacuoles" (oil-droplets) in lamprey visual cells—which, if true, would, of course, be the best of evidence for considering them cones.

Greeff (1900) was impressed with the ambiguity of the genus *Lampetra*, but followed Langerhans and Krause in his identifications. His drawing, though labelled *L. planeri*, must have been made from a small *L. fluviatilis*, as it shows the single outer nuclear layer of the latter species. Pütter (1912) added nothing original, but did call attention to the obscure and neglected mention of *P. marinus* by H. Müller, whose identifications, it will be recalled, were the inverse of those of later workers. It is quite clear that W. Müller's erroneous figure of "*P. marinus*" has kept all subsequent workers from discovering that in this form the situation is not so ambiguous as in *Lampetra*, for they would naturally be inclined to accept W. Müller's drawing over H. Müller's statement that the short-cells were much the more numerous. Mozejko (1912, 1913) made use of Kohl's pure-cone concept in arguing for the "primitiveness" of the lamprey eye.

Tretjakoff (1916) made a very great advance by applying neurological methods to *L. fluviatilis*, and while he identified the long-cell as a rod and the short one as a cone purely upon the basis of size, he found the long-cell to have a dendritic foot-piece and that of the short-cell to be a smooth knob, which by analogy with other cases of such differentiation would tend rather to support Heinrich Müller.

R. Kráuse (1923) followed Langerhans, W. Krause, and Tretjakoff in his designations, but claimed that in *L. fluviatilis* the short-cells out-number the long to a "not inappreciable" extent. Plate (1924) now pronounced the elements "undifferentiated"—neither rods nor cones—and was followed by Dücker (1924), whose material he supplied.

The most recent writer on the subject, Franz (1932), has put forward a new form of Schultze's pure-rod idea (foreshadowed by the views of Vogt and Yung, 1894), for he considers that in *L. fluviatilis* there is actually but a single type of element present, the bacillary layer being passively pseudo-stratified because of the bulky

[2] Greef (1900) has advanced the only other bit of evidence for rod-primitiveness, in his suggestion that the dendritic foot-piece of the cone is an advance over the smooth, compact rod end-knob. But in view of the ependymal origin of the visual cells (Walls, 1934*b*) the dendritic terminus is seen to be the more primitive one, the compact rod ending being adaptive to the multiple connection of rods to a bipolar neuron.

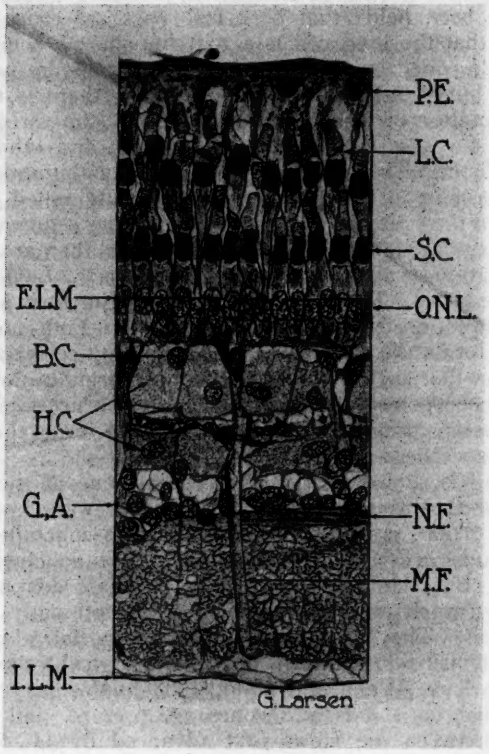


FIG. 1.

Retina of European River Lamprey, *Lampetra fluviatilis*. Kolmer's fluid; × 600.

P.E —pigment epithelium; L.C.—long visual cells (cones); S.C.—short visual cells (rods); E.L.M.—external limiting membrane; O.N.L.—outer nuclear layer; B.C.—bipolar cell; H.C.—horizontal cells; G.A.—ganglion and amacrine cells; N.F.—bundle of optic nerve fibres; M.F.—Müller fibre; I.L.M.—internal limiting membrane.

ellipsoids which interfere with close congregation.[3] He bases his case upon the cylindrical form of all outer segments as seen in his formalin and Bouin fixations—both most unsuitable for visual cells—upon the presence of myeloidal spirals in all outer segments, a rod-characteristic in his present opinion, though he himself admits that they have often been seen in cones (*cf.* Franz, 1913); and upon an alleged nocturnality of lampreys, of which more later.

[3] Franz was, of course, unaware that there are species in which one type of cell so greatly outnumbers the other as to render this view untenable.

From the above brief review it will be seen that all possible views have been held; that both cell-types are rods; that both are cones; that the long cell is a rod, the short a cone; that the long cell is a cone, the short a rod; that the cells are neither rods nor cones, but "undifferentiated." Clearly, there is need for a close examination of the criteria employed by the various investigators and for a careful evaluation of these and other possible means of distinguishing rods from cones in ambiguous cases.

The criteria upon which others have chiefly relied have been the length of the cells and the form of their outer segments. While rods in general are longer than cones in general there are exceptions such as certain snakes (*Dasypeltis, Tarbophis, Leptodira*) and most teleost fishes. The form of the outer segment is so prone to artificial alteration that the mere fact that both conical and cylindrical forms are claimed for each lamprey cell-type, coupled with the fact that such fixatives as alcohol, formalin, and Bouin's fluid have been principally employed, makes it necessary to withhold conclusions upon this important point so far as the literature to date is concerned.

One thing is, however, certain: at least one of the cells is a rod, for rhodopsin is present. If lampreys were known to be strictly nocturnal, it would be almost safe to conclude that both cells are rods in spite of Kühne's tentative conclusion to the contrary. But lampreys have no special adaptations for nocturnality, such as a tapetum or an exceptionally large lens or/and pupil. They do have at least one special adaptation for bright-light vision in the form of a physiological yellow colouration of the lens (Walls and Judd, 1933). We may tentatively conclude that both rods and cones are present, and have then to decide between the views first advanced by H. Müller and Langerhans respectively.

In re-examining the species of the genus *Lampetra* and in surveying other genera as yet untouched or but superficially studied by others, we may look for the following features with some hope of finding a meaningful differentiation of the two types of cells.

Form and size of the outer segment.—Herein lies the most characteristic visible difference between rods and cones. In a given retina, the rod ordinarily has the more massive outer segment and this is almost invariably perfectly cylindrical. The cone outer segment is smaller in sympathy with its higher threshold, and thus is conical unless exceptionally slender (see Rochon-Duvigneaud, 1917; Walls, 1934*a*). There are cases, however, where the rod and cone outer segments are about alike in size and shape, *e.g.*, certain urodeles, where they are bluntly conical, and the Macaque, where they are cylindrical and of equal

length (Garten, 1907). The absence of a differentiation is of no fundamental significance, however.

Presence or absence of rhodopsin in certain cells.—Visual cells which contain rhodopsin when dark-adapted are unquestionably rods, and very few cases are known of functional rods lacking this sensitizing pigment—such rods are among those which have originated secondarily from cones (certain nocturnal snakes, the night lizards, *Sphenodon*, etc.; Walls, 1934*a*). Cones never contain macroscopic amounts of rhodopsin and probably do not contain even a trace.

Relative extent of summation of the cell-types in bipolar and ganglion cells.—This criterion has been used by Woollard (1927) and by the writer (Walls, 1934*a*) as an index of sensitivity; for rods are always synapsed in multiple to bipolars while cones have more isolated conduction to the brain. If Cell "A" out-numbers Cell "B" more greatly in species "X" than in species "Y," and species "X" has much the higher visual cell—ganglion cell ratio, then Cell "A" is the rod and Cell "B" the cone.

Relative numbers of the cell-types in relation to pelagic vs *benthic, and diurnal* vs *nocturnal habits.*—This is a direct corollary of the Duplicity Theory: if Cell "A" out-numbers Cell "B" more greatly in species "X" than in species "Y," and species "X" is the more strongly benthic or/and nocturnal, then Cell "A" is the rod and Cell "B" the cone.

Relative numbers of the cell-types in the fundus as compared with the periphery.—In duplex retinae, cones are always concentrated in the fundus and more sparsely set in the periphery. If Cell "A" out-numbers Cell "B" much more greatly in the periphery than in the fundus, then Cell "A" is the rod and Cell "B" the cone.

Direction of migration in light and darkness.—This criterion was made use of by Laurens and Detwiler (1921) on the alligator, and depends upon the rule that if the visual cells of a given retina migrate at all, they move in opposite directions. If Cell "A" elongates in light and contracts in darkness while Cell "B" elongates in darkness and contracts in light, then Cell "A" is the rod and Cell "B" the cone.

Differentiation of the nuclei.—Cone nuclei tend to be larger, more ovoid, and nearer the limitans; rod nuclei smaller, more spherical, and in contact with the limitans only between cone nuclei. Cone nuclei tend to have small chromatin granules and linin; rod nuclei, large masses of chromatin and no linin (Menner, 1929). In amphibians, however, the nuclei are all of the "cone" type as here described, and the rod myoids being much the heavier (a unique situation) the result is that the *rod* nuclei are the nearer to the limitans.

Differentiation of the foot-pieces.—Cone foot-pieces are always heavy and dendritic, while rod fibres are often slender and terminate in a smooth knob. This difference holds only for forms whose rods very greatly out-number their cones. In amphibians, all foot-pieces are of the "cone" type.

We may now proceed to apply each of these criteria in turn to the eight species of lampreys studied by the writer: *Icthyomyzon concolor, I. unicolor, Petromyzon marinus unicolor, Entosphenus tridentatus, E. appendix, Lampetra fluviatilis, L. planeri, and L. lamottenii.*

I wish, first, to express my gratitude to the many persons who, with advice and labour, furthered the solution of the problem discussed in this paper. The accumulation of material of several of the species, preserved by the special methods necessary for the study of the retina, was made possible only by enlisting the co-operation of a number of conveniently located biologists. My thanks are due especially to Dr. C. U. Ariens Kappers of Amsterdam, Mr. Leonard P. Schultz of the University of Washington, Dr. David H. Thompson of the Illinois State Natural History Survey, and Dr. Albert M. Reese of the University of West Virginia. Facilities and supplies were kindly furnished by the Department of Zoology of the University of Michigan and the Faculty Research Fund of that institution.

Special mention must be made of the valuable advice and assistance received from Dr. Carl L. Hubbs of the Museum of Zoology of the University of Michigan and Dr. Simon H. Gage of Cornell University. The latter placed his Ithaca laboratory at the disposal of the writer during the breeding season of *P. m. unicolor* in two successive years.

The research was supervised by Dr. John F. Shepard of the Department of Psychology of the University of Michigan, and the writer is heavily indebted to him for excellent advice and keen criticism. He is also grateful to Miss Gladys Larsen for her careful work on the drawings.

Observations

Form and size of the outer segment.—In *I. concolor* (Wittmaack's fluid) and *I. unicolor* (Birch-Hirschfeld's modification of Zenker's fluid) the short-cell outer segments are relatively long and are sub-cylindrical, while the long-cell outer segments taper more sharply to a blunt point (Fig. 2). In *P. marinus* (Kolmer's, Birch-Hirschfeld's, Wittmaack's fluids) the short-cell outer segment is almost cylindrical and the long-cell member is very stubby and rounded on the end (Fig. 3). In *E. tridentatus*

(Birch-Hirschfeld) and *E. appendix* (Birch-Hirschfeld, Kolmer) the short-cell outer segment is a long, perfect cylinder, but that of the long-cell is a small cone (Fig. 4; cf. Fig. 2 in Walls, 1928*a*), Myeloidal spirals are especially evident in the short cells of *E. tridentatus*. In *L. fluviatilis* (Birch-Hirschfeld, Kolmer), *L. planeri* (Birch-Hirschfeld) and *L. lamottenii* (Zenker) the short-cell member is cylindrical, the long-cell outer segment smaller and

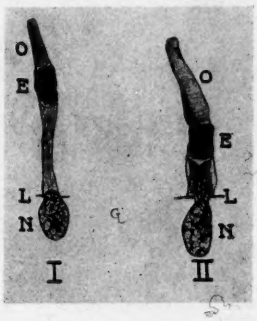


FIG. 2.

Visual cell types of *Icthyomyzon unicolor*. Birch-Hirschfeld's fluid; ×1000. I.—long cell (cone); II.—short cell (rod); O.—outer segment; E.—ellipsoid; L.—limitans; N.—nucleus.

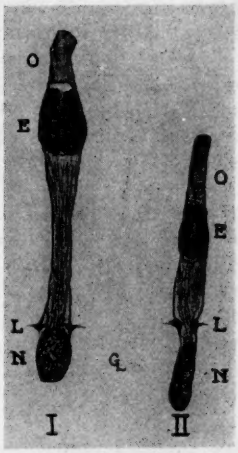


FIG. 3.

Visual cell types of landlocked Atlantic Lamprey, *Petromyzon marinus unicolor*. Wittmaack's fluid; ×1000. I.—long cell (cone); II.—short cell (rod); O.—outer segment; E.—ellipsoid; L.—limitans; N.—nucleus.

bluntly conical (Fig. 5). In the huge elements of *L. fluviatilis*, spiral threads are visible in both cases.

Thus wherever there is a clear-cut structural differentiation in this important feature, it is the short-cell outer segment which is large and cylindrical, whereas the long-cell member is smaller and more conical, though never sharply so as in many vertebrates. A staining differentiation is also usual, the short-cell outer segment taking the Orange G and the long-cell organelle the Aniline Blue in Mallory's triple stain, while in haematoxylin preparations the long-cell structure shows the greater affinity for the dye.

The differentiation of the outer segment is perhaps most sharp in *E. tridentatus*, but in all except the two species of the primitive

genus *Icthyomyzon* the evidence clearly supports Heinrich Müller's view.

Presence or absence of rhodopsin in certain cells.—The presence of rhodopsin in lampreys was confirmed on *P. marinus* by placing the excised retinae of five specimens, which had been in darkness overnight, in a vial of normal saline solution by ruby light. Removed to diffuse daylight and exposed before witnesses, the

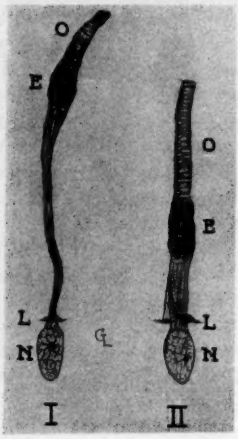


FIG. 4.

Visual cell types of Pacific Lamprey, *Entosphenus tridentatus*. Birch-Hirschfeld's fluid; ×1000. I.—long cell (cone); II.—short cell (rod); O.—outer segment; E.—ellipsoid; L.—limitans; N.—nucleus.

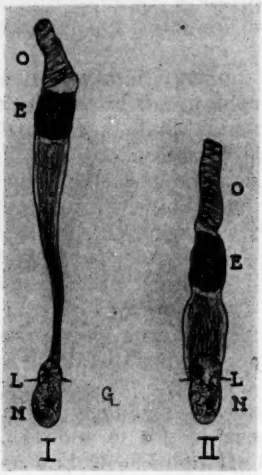


FIG. 5.

Visual cell types of *Lampetra fluviatilis*. Kolmer's fluid; ×1000. I.—long cell (cone); II.—short cell (rod); O.—outer segment; E.—ellipsoid; L.—limitans; N.—nucleus.

mass of retinae was seen to be truly purple (rhodopsin is usually red in colour), the colour fading in two seconds when placed in the light from a south window.

Attempts to determine which type of cell contained the rhodopsin, by the use of Stern's (1905) platinic chloride technique, were all failures. The method was tried on *I. concolor*, *I. unicolor*, *P. marinus*, and *E. appendix*. In all of these a yellow colouration was seen in sections of *both* dark- and light-adapted retinae, the colour not restricted to the outer segments, but being deepest in the ellipsoids. A proper Stern's test should show the outer

segments of only the rhodopsin-bearing type of cell stained yellow, in only dark-adapted material. The test is for some reason inapplicable to lamprey tissue or lamprey rhodopsin.[4]

At the suggestion of Dr. Selig Hecht an attempt was then made on *P. marinus* material to see directly, under the microscope, which cell-type contained rhodopsin. A Wratten "70" red filter, which passes only wave-lengths which do not bleach rhodopsin, was fitted to a substage lamp which was then used to focus upon a fresh dark adapted retina. The filter was then removed and the focus quickly improved, but no colouration of either type of cell was visible under the magnification needed to distinguish them.

Although direct methods failed, the writer was led to believe that it is the short-cell which contains the pigment. In *P. marinus* the amount of purple colour seen appeared far too much to have been located in the very small outer segments of the relatively scanty long-cells.

Relative extent of summation of the cell-types in bipolar and ganglion cells.—The fact that relatively few bipolar cells are present in lampreys was first noted by Greeff. Considerable summation must then occur, indicating that functional rods are surely present. Tretjakoff was unfortunately unable to determine, in neurological preparations, which type of visual cell is connected in multiple to the greater extent, so that the indirect method resorted to by Woollard on Primates and by Walls (1934*a*) on reptiles must also be employed here.

The discrimination of bipolar nuclei being difficult, and the certain identification of ganglion-cell and amacrine nuclei impossible in the writer's preparations, the extent of summation was roughly determined by comparing the number of visual-cell nuclei with the total of all other nuclei in the retina exclusive of the easily identified horizontal-cell and Müller-fibre nuclei, which must be excluded as they belong to non-conductive elements. The procedure, deemed adequate for the purpose—an exact determination being impossible and unnecessary—was to estimate the number of rows which would be formed by the projective nuclei if they could be rearranged into definite, compact rows (*cf.* Fig. 1) and then to compare this number with the number of rows in the outer nuclear layer.

One might suppose that this procedure would be vitiated unless the amacrine cells were somehow identified and excluded; but these elements are present in greatest numbers in those retinae in which summation is at a minimum and cone-to-rod ratios (and visual

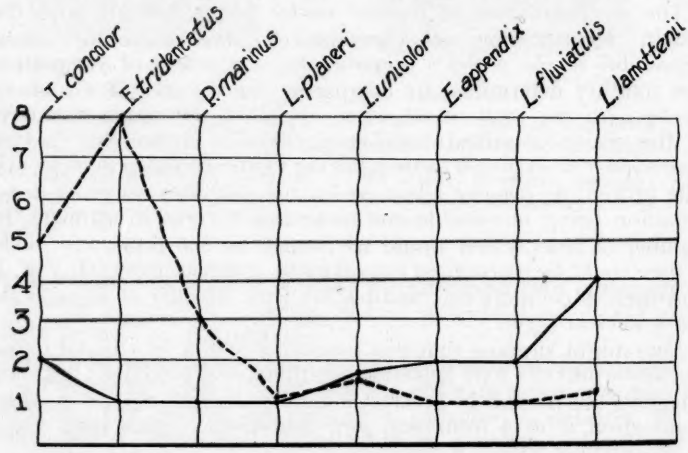
[4] Dr. Katherine Tansley (personal communication) states: "Stern's method gives a positive result only when there is a comparatively large amount of rhodopsin present. I have had negative results by this method in Vitamin A deficient rats when the retinae were distinctly, though only faintly, pink to the eye."

acuity) at a maximum (*e.g.*, birds), so that inasmuch as they are relatively abundant when bipolars, etc., are numerous, and scanty when much summation exists, their inclusion in the present determination cannot result in a masking of the true situation. The reason for these "comings and goings" of amacrines along with the straightforward elements of the visual pathway is, of course, wholly mysterious, as is the functional significance of the amacrine element in the first place.

The situation in the various species, determined as above, is as follows:—

	Rows of visual-cell nuclei:	Rows of projective (and amacrine) nuclei:
I. concolor	1 ...	... 2
I. unicolor	1½ ...	... 2½
P. marinus	2 ...	... 2
E. tridentatus	2 ...	... 2
E. appendix	2 ...	... 4
L. fluviatilis	1 ...	... 2
L. planeri	3 ...	... 3
L. lamottenii	1 ...	... 4

These ratios, reduced to a basis of one row of visual-cell nuclei, are shown on the accompanying graph along with the relative numbers of short-cells to long-cells (v.i.). It will be seen that



Solid line: no. rows neuron cell-bodies per row visual-cell nuclei.
Broken line: no. short visual cells per long visual cell.

there is a decided tendency for high numbers of short visual cells to go with low numbers of projective cells—that is, the species with the most short-cells have the most summation, and those with the most long-cells have the most isolated conduction.

This can only mean that the long-cell is the cone, the short-cell the rod.

Relative numbers of the cell-types in relation to pelagic vs *benthic, and diurnal* vs *nocturnal habits.*—The relative numbers of the cell-types were determined by counting the cells in a microscope field 290μ in diameter when the bacillary layer lay along the diameter of the field. The ratio in the fundus was found to be as follows for each species:—

I. concolor	...	...	5	short to 1	long.
I. unicolor	...	...	3	,, 2	,,
P. marinus	...	....	3	,, 1	,,
E. tridentatus	...	..	8	,, 1	,,
E. appendix	...	....	1	,, 1	,,
L. fluviatilis	...	...	1	,, 1	,,
L. planeri ...	...	...	8	,, 7	,,
L. lamottenii	...	...	5	,, 4	,,

Thus, in the species which live in the shallowest water, *L. fluviatilis* and the four brook lampreys *I. unicolor, E. appendix, L. planeri and L. lamottenii,* the ratio of short-cells to long is lowest—1 : 1, or nearly so. *I. concolor,* until the recent invasion by the land-locked marine lamprey, the characteristic lamprey of the Great Lakes, and the two marine forms *P. marinus* and *E. tridentatus* have at least the greatest depths available in which to swim, though it is not known what depths any of these species prefer.[5] In these three species the short-cells greatly predominate, so that if there is indeed a relation of cell numbers to depth of habitat, the short-cell is inevitably indicated as the rod.

Of previous investigators, only Franz (1932) has sought to apply the duplicity theory as a criterion. He states that *L. fluviatilis* becomes more active at nightfall, and that only at this hour does it come forth from places of concealment. Franz does not say whether this observation was made in the laboratory or in the field, on vegetating specimens or on those excited by the breeding season. Gage has recorded in several places that *P. marinus* moves only at night on its way upstream to breeding grounds. This is, however, in the same category with the nocturnal migrational

[5] A U.S. National Museum specimen designated as the type of the genus *Bathymyzon*, which Creaser and Hubbs (1922) have pronounced a *P. marinus*, was taken at a depth of 547 fathoms. The chorioids of the two marine lampreys are remarkably thick, that of *E. tridentatus* particularly. This is presumably adaptive to maintaining the circulation under the pressure of considerable depths.

flights of otherwise strictly diurnal birds; and photographs have often been made, in daylight, showing *E. tridentatus* leaping riffles on its way to spawn, much as does the salmon. All lampreys carry on their breeding activities in bright light, and no one has ever found them on the nests at night or even early in the morning. Professor T. L. Hankinson has told the writer that the easiest way he found to collect *P. marinus* in Oneida Lake in New York State was to go about for awhile in a white-bottomed motorboat and scoop the lampreys from the bottom of the boat with a dipnet as soon as the boat was stopped. Curiously, the following summer a red-bottomed boat was used and though the lampreys were as numerous as ever they were no longer attracted to the moving boat. Lampreys have given much inconvenience to swimmers during "marathon" swims (in daylight, of course) in Lake Ontario (see also Dymond *et al.*, 1929; Creaser, 1932).

Captive, breeding lampreys may be *photophobic*, as the observations of Reighard and Cummins (1916) and Lubosch (1902) attest, but the undisturbed lamprey is apparently diurnal in its breeding and at least not nocturnal in its feeding activities. Moreover, there is the yellow lens, a positive adaptation to diurnality (known elsewhere only in diurnal snakes, diurnal squirrels, the diurnal tree-shrew *Tupaia* and the diurnal gecko *Lygodactylus*) to account for.

Franz regards the sparse retinal pigment as an indication of nocturnality, but this—to anticipate—has the same significance as the similarly scanty pigmentation in the human; the pigment does not migrate, and there is, therefore, no need for much of it. Franz also makes the surprising statement that the "moderate size of the eye" predisposes to nocturnality, for the eye is "much larger in indubitably diurnal fishes, *e.g.*, *Esox*." Apart from the impropriety of comparing such diverse forms as *Lampetra* and *Esox*, it is common knowledge that *large* eyes are characteristic of nocturnal and crepuscular vertebrates; and this is no better seen anywhere than among the fishes.

There are no direct or indirect reasons for considering the lampreys nocturnal and hence pure-rod. The fairest possible estimate we can make of them at present is to say that they may be indifferent to night and day—for which behaviour only the duplex retina lays a basis. The writer would suggest that non-breeding *E. tridentatus* may well be quite nocturnal and that this species may prove to have a very pale yellow or even colourless lens.

The evidence from the habits of lampreys supports the conclusion that they have both rods and cones, but is too incomplete for particular species of diverse long-to-short-cell ratios to shed light upon the identity of the two cell-types.

Relative numbers of the cell-types in the fundus as compared with the periphery.—Cell counts were made in the periphery as described above for the fundus.[6] In the small eyes of *I. concolor*, *I. unicolor*, and *E. appendix* and in the case also of *L. fluviatilis* no difference was found, the same ratio obtaining throughout the retina. In the remaining four species the situation in the two retinal regions was found to differ as follows:—

	Fundus:	Periphery:
P. marinus ...	3 short to 1 long.	4 short to 1 long.
E. tridentatus ...	8 „ 1 „	15 „ 1 „
L. planeri ...	8 „ 7 „	1 „ 1 „
L. lamottenii ...	5 „ 4 „	4 „ 3 „

It will be seen that there is a concentration of long-cells in the fundus, marked in *P. marinus* and especially so in *E. tridentatus*, insignificant in the degenerate *L. lamottenii;* and that only in *L. planeri* is there a reversed situation, the long-cells being slightly more frequent in the periphery.

Such evidence as there is here—and it is again excellent for the marine species—supports Heinrich Müller's view that the short-cell is the rod, the long-cell the cone.

Direction of migration in light and darkness.—There has been no certain demonstration by previous investigators of a migration of either type of visual cell. Kohl and Franz have thought that photomechanical changes might occur in lampreys, and Tretjakoff describes an extensive migration of the retinal pigment in *L. fluviatilis*[7] accompanied by a 5 per cent. shortening of the short-cell myoid in light. This latter observation, if verified, would support Langerhans and Krause; but Tretjakoff fails to mention duration of exposures, water temperatures, number of animals, number of cells measured, etc.

The writer's material of the various species, light- and dark-adapted by himself or others, received varying treatment with respect to light strength, water temperature, etc., to be mentioned in connection with the respective species.

All material received similar treatment in preparation and study, however; the excised eyes of the larger species and the entire heads of the brook types were embedded by the hot celloidin method (Walls, 1932) and the eyes sectioned at 10μ in their median vertical planes. Mallory's triple stain was found especially valuable for

[6] These ratios as seen in sagittal sections are, of course, not the true ratios which would be seen in tangential views of the mosaic, except in the case of the 1:1 proportion.

[7] On the other hand Gage (1911—unpublished) found no pigment migration in *P. marinus*.

differentiating clearly the parts to be measured, and some sections were mounted unstained to afford a clear view of the retinal pigment. A portion of the fundus was chosen in which the retina showed no distortion and the full length of the ocular-micrometer line was placed at a level representing the average position of many pigment-process tips, ellipsoids, etc. In this way the average length of a 100 or more short- or long-cell myoids, pigment streamers, etc., was quickly obtained as accurately as could have been done by any other method. The following measurements were made on each eye:—

(*a*) The distance from the limitans to the short-cell ellipsoids.

(*b*) The distance from the limitans to the long-cell ellipsoids.

(*c*) The thickness of the mass of retinal pigment.

(*d*) The thickness of the retina. This last was taken to make possible an expression of the extent of migration in per cent. of retinal thickness, so as to average more fairly the individuals of a species; but as will be seen, there was no need to resort to this refinement.

All dark-adapted material was, of course, killed under ruby lights and the material allowed to fix in complete darkness. Light-adapted specimens were killed and fixed in the light. No adapted material of *I. concolor* or of *E. tridentatus* was obtainable. The data for the experimented species follow:—

I. unicolor

Twelve specimens were placed in diffuse daylight for three hours, then in a jar with a white background and substrate, surrounded closely by six 60-watt lamps. After three hours, six animals were killed. The room was darkened for three hours, when the remaining six were beheaded. The water temperature was kept between 18°C. and 22°C.

The long-cell myoids averaged 1·2μ longer, the short-cell myoids 0·35μ longer, in the light group. Here also the pigment band averaged 0·8μ thicker. These figures are of no consequence, and it is obvious that there are no photomechanical changes in this species.

P. marinus

The water temperature was constant at 17°C. in both light and darkness, and the animals stayed overnight at this temperature before adaptations were begun. Light exposures were made with the animals swimming in a white sink, in daylight supplemented by a 300-watt lamp in a mirror reflector.

The six animals in each group were exposed for one hour (one

specimen), two hours (one specimen), and four hours (four specimens). The dark group received a preliminary light-exposure of four hours.

The long-cell myoids averaged 1·47μ longer, the short-cell myoids 0·17μ shorter, in the light group. The pigment bands averaged 1·74μ thicker in the light group, but the retinae of these six animals averaged 11μ thicker. Such small differences were deemed negligible.

E. appendix

In an earlier paper (Walls, 1928*a*), the writer reported the absence of photomechanical changes in this species. Later experiments were made at a constant temperature of 15°C. Light adaptations were made in a white-lined box seven inches square, with a 60-watt lamp in a parabolic reflector pulled down over a four-inch hole in the lid, which could be covered for dark-adaptations. A light-tight air inlet insured sufficient oxygen.

Twelve specimens were placed in light for three hours; six were killed, and the remaining six dark-adapted for three hours. The long-cell myoids averaged 1·42μ longer, the short-cell myoids 1·03μ longer, in light. The pigment band was 1·03μ thicker in the light group.

In a second series, six animals were light-adapted for 24 hours; three were sacrificed and the other three beheaded after 24 hours in darkness. The long-cell myoids were 0·97μ longer, the short-cell myoids 0·5μ shorter, in light. The pigment band was 2·1μ thicker in the dark group. Obviously, there are no migrations in this form.

L. fluviatilis

The water temperature was not recorded. Ten animals were left in a dark-room overnight. They were then flooded with bright artificial light and killed in twos and threes at intervals of one-half, one, two, and three hours. Nine other specimens were left in the dark-room, flooded with light, overnight. The lights were then turned off and fixations made after one-half, one, two, and three hours as before. The purpose of these various lengths of exposure was, of course, to determine the minimum times of the adaptations, if any.

The long-cell myoids averaged 0·88μ shorter, the short-cell myoids 0·68μ longer, in light. The pigment band was 3·64μ wider in the dark group. The insignificance of these differences is emphasized by the fact that they seem to show the short-cell elongating by about the same amount which Tretjakoff claimed it to shorten, while the pigment "migration" is in the wrong direction! There are no photomechanical changes in *L. fluviatilis*.

L. planeri

Water temperature was maintained practically constant at 20°C. Twelve animals were used in two equal groups, the exposures to each situation varying from one to twelve hours; all were given a preliminary 12 hours' exposure to darkness. The adaptations were made in a dark-room, three 100-watt lamps furnishing the light.

The long-cell myoids averaged 0·39μ longer, the short-cell myoids 0·8μ shorter, in the light group. The pigment band averaged 0·59μ thicker in the light-adapted specimens. Here, again, the figures are meaningless.

L. lamottenii

Water temperature was not kept constant. Exposures were made in a dark-room, the animals being in a jar which rested on white paper and was surrounded by four 60-watt lamps at six inches distance. Eight animals were placed in darkness and pairs of them killed each hour for three hours. The remaining pair was illuminated for one hour and sacrificed.

The long-cell myoids averaged 0·7μ longer, the short-cell myoids 0·9μ shorter, in the light animals. The pigment band averaged 5·3μ thicker in the light specimens. Once more, there is no evidence of photomechanical changes.

The total absence, in lampreys, of these phenomena seems surprising in view of the fact that they are more and more conspicuous as one goes down the vertebrate scale toward the teleost fishes, while the pupil reaction (of similar dazzle-preventive function) shows the opposite trend, being absent in the teleosts and reaching its peak in the mammals (Walls, 1928*b*).

Photomechanical changes are secondarily lacking in duplex ophidian retinae, some of which, as in *Tarbophis*, are strikingly like lamprey retinae in visual-cell pattern and are similarly "statically dark-adapted." They are lacking also in mammals; but in all of these cases the great mobility of the pupil is sufficient explanation.

One can only conclude that the lampreys, whose pupils are motionless, are simply too primitive to have evolved a pattern of photomechanical migrations.

Differentiation of the nuclei.—This matter was omitted entirely from the review of literature above, because of the many contradictions resulting from the crude technical methods of the earlier workers, which so shrank and distorted the tissue as to shift the nuclei from their normal locations and elongate them abnormally.

In *I. concolor* the outer nuclear layer is irregular, but fundamentally single. Either type of cell may have its nucleus against the limitans or slightly distant from it. This is true also of *I. unicolor*, whose outer nuclear layer is more nearly double. The outer nuclear layer of *P. marinus* is definitely double and the long-cell nuclei always touch the membrane, while those of the short-cells may lie at any level in the layer. In *E. tridentatus*, on the other hand, it is the long-cell nuclei which are most irregularly distributed, though none of the nuclei of either type are normally in contact with the limitans. The outer nuclear layer of *E. appendix* is quite precisely organized, the long-cell nuclei invariably lying against the limitans or even protruding through it. The short-cell nuclei form a definite second layer.

The visual-cell nuclei of *L. fluviatilis* form a compact, single layer; for in this form the cells are not very closely congregated. In *L. planeri* the layer is triple[8] and precisely formed with the long-cell nucleus always against the limitans. The *L. lamottenii* material was not sufficiently well preserved (Zenker's fluid) to permit of rigid conclusions.

It is clear that wherever there is a well-marked differentiation of position, the long-cell nuclei always occupy the place of the cone nuclei of higher vertebrates. There is, however, no regular differentiation of shape or size of nuclei in any species, and the organization of the chromatin in all visual-cell nuclei of all species is that described by Menner for cone nuclei in general.[9]

There is thus little or no evidence from the nuclei pointing to a definite conclusion—but such as it is, it tends to indicate that the long-cell is a cone and the short-cell a rod. The basis of the nuclear differentiation in higher vertebrates, it should be noted, is entirely unknown and in any case is assuredly not fundamental to the physiological differences between rods and cones.

Differentiation of the foot-pieces.—Here we must rely solely upon Tretjakoff's demonstration of a dendritic terminus in the case of the long-cell and a smooth knob ending in the short element of *L. fluviatilis*. If this difference means anything whatever, it is that the long-cell is the cone, the short-cell the rod; for as Pütter

[8] Because the first specimens supplied by Mr. Schultz were small compared with the average of European material, it was thought that this might be a juvenile characteristic, and that the layer might thin out as the eye grew. Very large individuals showed the same situation, however. The triple condition has not been seen by any European observer. Perhaps a subspecific difference of the West Coast *L. planeri* population may lie here.

[9] There is, of course, no more reason for considering the lamprey retina pure-cone, on this basis, than for similarly terming the visual cells of amphibians all cones. The usefulness of Menner's criterion is decidedly limited. Menner unfortunately failed to include a Cyclostome in his extensive survey of outer-nuclear layers.

(1912) has emphasized, all vertebrates which exhibit any foot-piece differences have dendritic cone-feet and compact rod end-knobs.

Conclusions

From the above descriptions, it is obvious that in the lampreys we are not dealing with "undifferentiated" cells. Nor can the lamprey retina possibly be considered either pure-rod or pure-cone. It is certain that both rods and cones are present, and it is equally certain that Heinrich Müller alone has hitherto held the correct view—that the long cells are cones and the short cells rods. Though the differentiation is "perfect" only in *E. tridentatus* and (histologically) "poor" in the genus *Icthyomyzon*, there is surely no reason to suppose that these identifications do not hold for all Holarctic lampreys. The situation in *Geotria* and related genera is entirely unknown, though Plate (1924) has given observations on a macrophthalmia of *G. chilensis* which he himself says was "schlecht konserviertes."

The presence of both rods and cones in these, the most primitive vertebrates, makes it impossible to rely, as Schultze did, upon comparative adult histology to solve the problem of the order in which the rod and cone originally evolved. The writer hopes eventually to present an embryological attack upon this problem, for the comparative histogenesis of vertebrate retinae, structural and physiological, appears now to be our sole possible source of evidence.

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SOME NOTES ON THE TREATMENT OF STRABISMUS*

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IT is the object of these remarks to outline a routine of treatment which has proved, in my hands and those of the group working in our clinic, very satisfactory. Many will differ with me on the details of operative procedure, for there are a number of operations for strabismus, each of which will give good results in the hands of those familiar with it. On the other phases of treatment, however, it seems that we should agree fairly well. After our two years' experience with a special clinic for orthoptic training I think we may set down certain definite facts as to the possibilities and limitations of such training, and give it its definite place in the treatment of strabismus.

The first step in any case is, of course, a complete examination, including refraction under atropine in children under 10 years of age. In older children homatropine is usually as effective. At least our retinoscopy under homatropine will tell us whether cycloplegia is complete and in a few cases will indicate the need for atropine refraction.

In concomitant convergent squint with hyperopia or hyperopic astigmatism as much of the full correction as will be tolerated is

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prescribed. If the full correction reduces vision too much, the correction prescribed will be increased to the full correction as rapidly as possible.

Cases with less than one dioptre of hyperopia offer less chance of correction with glasses alone, but may show some improvement with bifocals, or grab fronts, +2·0 D. sph. being added for near. It is also worth trying this in cases which are straight for distance but show 10° to 15° of convergence when reading. It is hard to estimate what proportion of cases will become straight with glasses, since the chance of this depends on the age at which treatment is begun, the degree of refractive error and other factors. Dr. Guibor's[1] control series, observed very carefully after refraction and with no other treatment except atropine or occlusion, included cases of concomitant squint of all types and degrees, in which refraction was done quite early, usually below the age of six years. After six months 12·5 per cent. had become straight, while after 18 months 30 per cent. were straight with glasses. Twenty per cent. remained straight for brief periods without glasses. Most of these were, of course, cases of concomitant convergent squint.

In divergent squint, little is to be expected of correcting the refractive error, as a rule. Non-operative measures must here be confined to attempts to improve amblyopia and to fusion training.

With regard to the improvement of vision in amblyopic eyes, opinions vary widely. Those who practise prolonged uni-ocular occlusion with a fixed dressing for weeks and months report the best results. Delord[2] by covering one eye for from four to six months obtained improvement of vision in 35 cases. One improved from 1/10 to 2/10, one from 1/50 to 3/10, and one from 2/50 to 5/10. Herzau[3], from the Leipzig clinic, reports 37 per cent. of cases with definitely improved vision.

Peter[4] reported that 50 per cent. showed improvement.

Our results with amblyopia have been far below those just mentioned. It has been impossible to obtain co-operation for prolonged uni-ocular occlusion in most cases. It is impossible as a rule where the vision of the amblyopic eye is below 20/200, and only a few parents will carry it out satisfactorily in other cases. In several cases, however, in which co-operation was excellent the results were disappointing.

With occlusion for one or two hours a day and the use of atropine results have not been at all remarkable in our hands.

Dr. Guibor has used atropine a great deal and also a system of reducing vision in the good eye by under-correction with atropine or the use of Snell's lined glasses. This is of value in overcoming suppression of the poorer eye and as an aid to orthoptic training, but actual improvements in vision have not

been striking. In cases with less than 20/200 vision he saw no improvement. A few cases with vision of 20/100 improved to 20/80. Ten cases with vision of 20/50 were recorded as showing improvement, sometimes to 20/20, but these were chiefly children three to four years of age in whom the initial vision could hardly be reliable. One is inclined to think of possible errors in recording vision in the series of authors reporting such marked improvement as is done by Herzau and Peter. But it must be said that we have

FIG. 1.

Case 1.—Convergent strabismus before training.

FIG. 2.

Case 1. After three months orthoptic training.

FIG. 3.

Case 2. Convergent strabismus before training.

FIG. 4.

Case 2. After one year orthoptic training.

not given prolonged uni-ocular occlusion a fair and prolonged trial in a large enough number of cases to form a definite opinion. As the lower limit of vision with which orthoptic training could be carried out, Dr. Guibor found 20/80 in most cases. Patients with poorer vision could be trained to fuse the larger test objects, but did not obtain much benefit from the exercises. This agrees fairly well with the opinion of Cantonnet[5] who is most enthusiastic as to the results of orthoptic training in most cases.

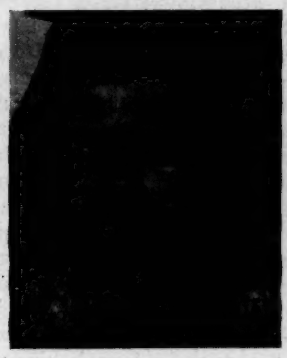

FIG. 5.

Case 3. Convergent strabismus before training.

FIG. 6.

Case 3. After nine months orthoptic training

FIG. 7.

Case 4. Convergent strabismus before training.

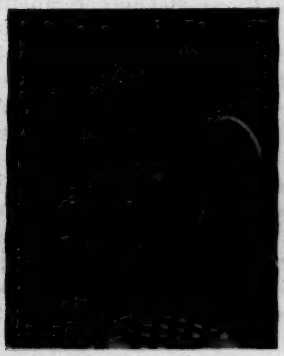

FIG. 8.

Case 4. After six months orthoptic training.

In attempting to decide which cases are suitable for orthoptic training or other measures, Guibor classifies his cases. First *paralytic squint* must be ruled out, a proceeding not always perfectly easy with small children. These cases, especially of abducens palsy, are now considered suitable for surgery at the outset, since many good results may be obtained with tendon transplantation. Next to be ruled out are cases of *pseudo-strabismus*, patients with a wide or narrow angle gamma. Measurement of the angle gamma and the cover test are all that is necessary.

Most important is the group of *accommodative strabismus*. These cases have hyperopia, usually of fairly high degree, and show a marked improvement in the angle of squint under atropine. Many become straight on full refractive correction and atropine. The use of additional correction for reading is here often of assistance. Fusion training seems to be of value in hastening the process, but is not always necessary. This class is a large one and furnished the greater part of the 30 per cent. in Guibor's control series which became straight without any training.

Strabismus due to defective fusion is a class necessary to explain those cases with good vision and little or no refractive error, which show no change in the angle of squint under atropine. Many cases of divergent strabismus are of this type, especially the cases of intermittent or latent divergence. Cases of alternating squint are used as the type of this group, and such cases are stated by Peter and other authors to have complete absence of the fusion sense. Although nearly all cases of squint have difficulty in fusion and may be unable to fuse when first seen—most cases acquire this ability very rapidly. In three cases of alternating squint we have been unable to develop any fusion ability. In four equally typical cases, however, good fusion and depth perception have been developed. In two of these, of 25° and 10°, the squint has been corrected with glasses and training. In the two others the angle has remained unimproved in spite of good fusion in the stereoscope. Hence, while we may say that the fusion ability is under-developed in such cases, it cannot be stated that it is absent. This agrees with what we know of the anatomy and physiology of vision, as expressed by Adler[6]. It is in this group that fusion training is most important. In it improvement may be obtained in most cases and full correction in a number of cases of low or moderate degree. Where surgery becomes necessary, fusion training before—and especially after—operation will greatly enhance the benefits of surgery and do much to insure their permanency.

Strabismus with amblyopia.—Whether amblyopia is the cause of strabismus or *vice versa* in this group, it is certain that the results of refraction are less satisfactory in proportion to the degree

of amblyopia and that where vision is less than 20/100 or 20/80, fusion training is of little value. Attempts will be made to improve the amblyopia, without, however, expecting too much, and if hyperopia is present, the effect of glasses for six months to a year will be watched. After this time, there is no reason for postponing surgery.

Strabismus associated with anisometropia may be considered a variety of the above group if the anisometropia is of high enough degree to prevent binocular vision with correction. It is possible to attain binocular vision in some such cases by means of the iseikonic lenses of Ames which equalize the size of the retinal images. As far as I know, no cases in which squint has been corrected by their use have been reported.

Strabismus due to muscular abnormalities may be used to describe cases in which none of the above factors is present and in which tests reveal a weakness or over-action of certain muscles. In convergent squint of this type uni-ocular abduction can be maintained for only a short time without difficulty, as shown by nystagmoid movements. In cases of vertical strabismus where no paresis can be demonstrated, a muscular anomaly must always be assumed to exist. In this group, surgery is indicated without preliminary training. A trial of other measures may be necessary before certain cases can be placed in this group.

Cutting across this classification, but equally important, is a division of all types into squint of high and low degree. Guibor found that in his group of 48 cases, including all types of concomitant strabismus, where the angle of squint was 15° or less, 84 per cent. became straight after refraction and orthoptic training, while where the angle was more than 15°, only 16 per cent. became straight. In this latter group, therefore, it is often more practical to advise surgery without a too prolonged trial of glasses and training. The operation should be followed by training which can be much more easily conducted when the eyes are straight or nearly so. I have been especially gratified with the effect of orthoptic training in a small group of cases with 5° or 10° of squint remaining after operation. It has been my experience that such cases usually became worse in the days when no post-operative training was attempted. For a large part of this group, however, in which training was carried out immediately after operation, the remainder of squint was seen to disappear completely within two to three months, and the eyes have remained straight.

There is only time to outline the methods of training which have proved of value in the clinic. I am borrowing freely from Dr. Guibor for this. Patients come once a week and are given training for 20 minutes to an hour. In this clinic group, usually no home

training was conducted, for practical reasons. In private practice, where parents are co-operative, training is done chiefly at home, with office visits seldom oftener than once a month, at which progress is checked and further work outlined. Usually additional prisms are prescribed for use during the exercises. Where co-operation at home is not good, more frequent office visits should be made. One is inclined, however, not to insist on many office visits, for fear patients will feel that the training is being erected into a racket. Hence clinic patients will, on the whole, be given a fairer trial of training than private patients. At the first visit a careful record is made of the degree of squint, and fusion ability.

The suppression usually present is the first thing to overcome. For this the large synoptophore of Maddox is ideal, since the light may be cut down before the fixing eye till the squinting eye alone is able to see its chart. Then the light is increased before the fixing eye till both charts are seen. They may be brought together and fused at the first visit. The same effect may be obtained by placing a very bright light before one tube of Worth's amblyoscope or by using larger objects before the squinting eye in the stereoscope. Prisms are usually necessary to approximate the images. These will be base out for convergent and base in for divergent squint. As soon as fusion with the stereoscope is possible exercises are conducted with this instrument since more stereoscopes and a greater variety of charts are available. We have found no real advantage in the more complicated instruments employing moving objects.

In nearly all cases with vision of 20/100 or better in the squinting eye, fusion is possible with the simpler instruments with the aid of prisms. These are used in grab-fronts or placed in holders in the stereoscope. The stereoscope itself has prisms which allow the correction of 5-7 degrees of deviation at the extremes of its slide.

It has been found that the easiest charts to fuse are not the flat pictures, such as the bird and the cage, but simple figures showing definite perspective in which one or more parts are common to both pictures. Such are the "E" series of Wells and all of the Sattler charts. Guibor has just prepared a set of charts for children and adults all of which have perspective and are graduated in order of difficulty. They are split charts, like the Sattler charts, hence possessing two advantages over the Wells charts, which have both pictures printed on one chart. The split charts may be reversed, thus reversing the depth impression so that it may not be learned by children. They may also be placed at any distance apart in the special holder, so that each pair of pictures may be used in all the positions of the Wells "H" and "I" series, which saves much changing of prisms and often

obviates their use at the beginning. A number of different sets of charts are advisable, to vary the exercises and prevent children from learning what they are supposed to see. A number of pictures are kept out as check charts, so that they can never be learned, and provide a check on suppression and depth perception. It is surprising how rapidly depth perception is obtained in children who have squinted for years, and we agree with Cantonnet that persons aged 25 or 30 years may obtain it. A number of such

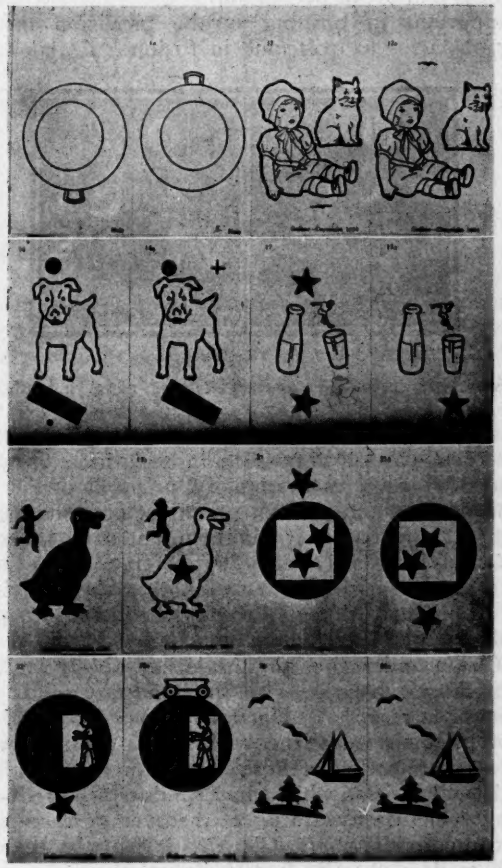

FIG. 9.

Group of Guibor's charts, pairs of split charts of increasing difficulty.

patients have been checked with the Howard apparatus, and there is no question that true binocular depth perception is present. We have learned to watch for pseudo-binocularism, the condition in which, by rapid alternating movements, both charts are seen and appear to be superimposed. This is learned by watching the patient's eyes in the stereoscope for which purpose the top of the stereoscope shield should be cut away. A number of patients go through a stage of pseudo-stereoscopic vision in which the depth impression is seen reversed. This usually yields rapidly to true stereopsis and depth perception.

Most important in training is the provision of constantly increasing obstacles to overcome in fusion. As soon as objects

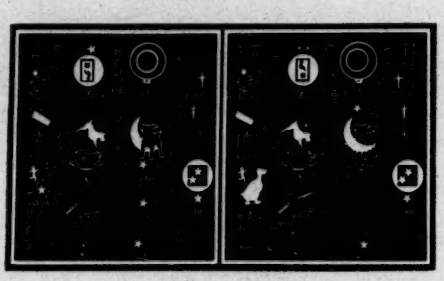

FIG. 10.

Review chart, including a number of figures of varying difficulty.

can be fused, fusion amplitude is developed by moving the arm of the stereoscope as far as possible in each direction while fusion is maintained. This gives a range of 7 prism dioptres. When this is accomplished without prisms, prisms of opposite sign, base in for convergent and base out for divergent squint, are provided, and these are increased until 20° before each eye are overcome. It is surprising how rapidly the original prism necessary to obtain fusion may be reduced, and opposite prisms of increasing strength overcome.

When fusion and fusion amplitude have been well developed, a check of muscle balance with the Maddox rod is made, and duction power is recorded. Duction is then developed further by the use of prisms as described. When a vertical imbalance is found as a complication of horizontal squint, it is often well to correct this with prisms which may gradually be reduced.

The stages in fusion training of the average case may be seen in the accompanying chart (Chart). It may be seen that most progress is made in the first four to six months, if co-operation has been good and that only slight additional improvement may be expected after this time.

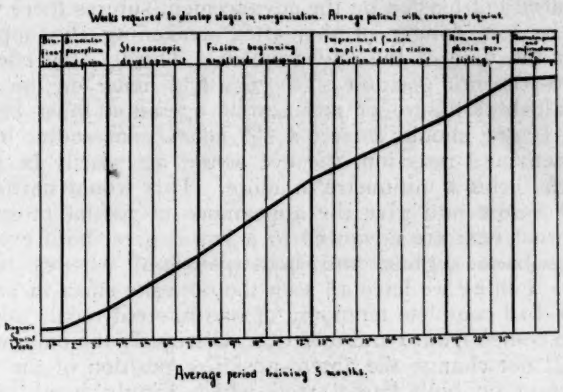
Weeks required to develop stages in reorganisation. Average patient with convergent squint
Stereoscopic development
Fusion beginning amplitude development
Improvement fusion amplitude and vision duction development
Retained of phoria per reading
Average period training 5 months.

FIG. 11.

Stages in orthoptic training.

As to the age when operation should be performed, I agree with Peter that when a fair trial of non-operative measures has been given and further progress is at a stand-still, operation should be advised, regardless of age. It is a great pity to have any child get to the age at which it is sensitive, self-conscious and set apart from its fellows by such a ludicrous deformity which is so easily remediable.

In discussing operative procedures, it would not be profitable to describe in detail anyone's favourite operation. No one operation is suitable to all cases of squint, and the important thing to have is a reasonable plan of the procedures or combinations of such which work out best in particular types or degrees of squint. Theoretically, we should classify our cases into those due to over-action or insufficiency of a muscle-group and treat them by respectively lengthening or shortening the offending muscle. But practically in nearly every case of concomitant strabismus we have a combination of both factors, insufficiency of one muscle followed by spasm of its opponent or *vice versa*. This is a theoretical reason, but I would like to point out other reasons for a procedure which we have come to adopt in nearly all cases of concomitant squint higher than 20°. I refer to simultaneous operation on both lateral recti of one eye. First of all, many patients with an amblyopic eye refuse to have any operation on their good eye so that what is done must be done to the amblyopic eye. Second and most important, a much greater effect can be obtained from an advancement, for example, if it is combined with a recession than when it is first done alone and followed later by recession.

If one is afraid of tension on the advancement sutures there would seem to be less danger of this after weakening the opposing muscle at the time of the advancement. Thirdly, the effect on the antero-posterior position of the eye and hence on the width of the palpebral fissure of any squint operation must be considered. If one should correct a 35° convergent squint by one advancement and resection, the eye would necessarily be pulled back in the orbit a millimetre or more. This would narrow the palpebral fissure and give the appearance of partial ptosis. If both external recti are advanced to a less degree, both eyes will be pulled back slightly and both palpebral fissures become narrower. I think we have all seen the opposite effect in patients who have had complete tenotomy of one internal rectus allowing the eye to come forward and turn out. Obviously the only method which will not change the antero-posterior position of the eye is an operation on both lateral recti which simply turns the eye around without pulling it in either direction.

When the angle of squint is large, or even over 25°, I prefer a resection and advancement combined with a very moderate recession. This never interferes with convergence for practical purposes, and with it one can correct at least 35° and sometimes 45° in a single operation. Rather than run the risk of convergence insufficiency the recession is never more than 4 mm., and if any squint remains, it can be cared for by a later recession on the opposite eye. Since beginning orthoptic training at once in such cases, a second operation has less often been necessary.

I have no particular technical tricks about the advancement operation, except that a slight simplification of the Worth suture has seemed quite effective and that no attempt is made to close the conjunctiva with the advancement sutures. An untied running conjunctival suture is employed, which is especially convenient to remove in children. Removal of the deep sutures is apt to be troublesome, and in children it is best to give a few whiffs of gas for this purpose.

Recession is done by two methods. When general anaesthesia must be employed, one must estimate beforehand the amount of recession to be done and do it without regard to the position of the eyes under the anaesthetic. In this, Jameson's method is ideal, but I employ two double-armed sutures, and only pass one needle of each pair through the scleral fibres. When operating under local anaesthesia, one will often prefer a type of recession which may be varied until the desired position is obtained. The operation is really a guarded tenotomy which has been described by many authors, and recently by Mott[7], and Wilkinson.[8]

In a case of convergent squint, for example, the internal rectus is first exposed, clamped, and cut from its insertion. Two double-

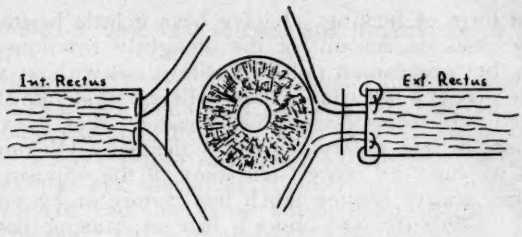

FIG. 12.

Technique of guarded tenotomy combined with advancement.

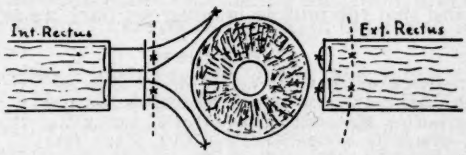

FIG. 13.

Technique of guarded tenotomy combined with advancement.

armed sutures are placed through the tendon, the forceps is released and the advancement on the opposite rectus is performed. Then the sutures through the internal rectus are placed through the insertion and conjunctiva and given one turn of the knot. This is then tightened until the desired position is obtained when the knot is tied. It is impossible for the muscle to slip back further, and only occasionally does the effect turn out to be less than desired. This may be due to a return of function in a muscle partially paralyzed by novocaine, or the muscle may become attached further forwards than the position obtained on the operating table which is, of course, prevented by the Jameson technique. In some cases, as in recession of a vertical muscle, I have prevented this slipping forward by a suture placed around the tendon and with one bite through the sclera beneath it when the desired position was obtained.

In squint of slight degree I was trained to employ tucking by the Banister-Valk technique. There were some disappointments, even in such cases, and a tendency in a few cases for the squint to recur after an apparently perfect result. Then there was always the hump which required months or years to disappear. And in a few cases the buried catgut remained unabsorbed and formed small granulomata requiring later removal. So recession has been more and more employed in such cases, and with very satisfactory results. Here and in the phorias the O'Connor operation seems to have a very definite place. Certainly it appears to be the safest

and surest form of tucking. I have been a little hesitant to use it in many cases on account of the unsightly reactions which I have seen, but one cannot talk to Californians without a renewed decision to give it a fair trial in cases where a moderate shortening is indicated. It seems impossible, however, that it can replace advancement where a large effect is desired. O'Connor often reinforces its effect by central tenotomy of the opposing muscle, but this has always seemed much less certain and accurate than recession. Certainly, O'Connor's fear of causing convergence insufficiency by a recession, whatever his models may show, is not borne out by practical experience with many recessions on the human eye, it being understood that the operation is carefully performed, and that the muscle is never set back more than 5 mm.

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FAMILIAL MACULAR DEGENERATION

BY

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FROM time to time during the past 15 years macular degenerations have been met with here, in the course of routine fundus examinations, which presented certain peculiar similarities in appearance. It has been customary to use expressions such as "beaten brass or silver," "coppery sheen," etc. to describe the ill-defined macular fundus changes seen. I have for long regarded some of these cases as familial degenerations, as on rare occasions such appearances have been met with in more than one member of the same family. Moreover, they did not resemble any fundus change, with which we were familiar, connected with known pathological states, except, perhaps, the ill-defined changes which are sometimes seen after the resolution of bilateral subhyaloid haemorrhages. Owing to the difficulty which exists in obtaining accurate family histories from our South Indian patients, striking sibships are rarely forthcoming, but a family group met with

recently seemed of sufficient interest and importance to record in some detail.

In September, 1933, Dr. R. J. Dyson, Chief Medical Officer, Madras and Southern Maharatta Railway, Madras, kindly asked me if I would examine the three sons of a station-master from Marmagoa. Their eyesight was failing rapidly and the father had consulted various eye specialists in other parts of India without satisfaction. He had one other child living, a girl who was apparently normal. On September 22, 1933, the father, of mixed Indian and Portuguese descent, came to the hospital with his three sons, aged 14, 12 and 11 years. They all presented defective visual acuity, an abnormally dull mental condition, and remarkable heads. These features were more marked in the eldest, less marked in the youngest.

Before describing each case in detail, the father's statement may be given. He said that neither he nor his wife had defective vision, nor had there been any consanguineous marriages, or defective vision in earlier life, for at least two generations. There was no venereal disease in the family. His wife was also of mixed Portuguese-Indian descent. Six children were born to them. The first-born died in the sixth year, the second-born died in the fifth year. He could not say for certain whether there was anything wrong with their eyes, nor if the shape of their heads was peculiar. Of the remaining four, the youngest, a girl of seven years of age, had no trouble with her sight. There was one miscarriage after the fourth child. The three boys had developed very bad sight, and as the trouble seemed to be progressive, he was very anxious about them.

The eldest living boy, aged 14 years, was attending elementary school till his eleventh year when he passed an examination in Portuguese. The school-master discovered on the examination day that the boy was holding the book very close while reading. From that year forward the sight had been getting steadily worse. On the date of the examination, three years back, when the defect of the eldest was noted, the second boy, then nine years of age, was examined and found to have bad vision also. His condition subsequently became steadily worse. The youngest boy sat for his examination at eight years of age and passed. No defect of vision was noticed at that time and an ophthalmic surgeon who then examined all three, said that the youngest was not suffering from defective sight whilst the other two were. In 1932 the youngest boy was found to be keeping the book close to his face while reading and from that time onwards his vision gradually failed. In his anxiety about the sight of the boys, the father consulted various doctors. In one hospital each boy received anti-specific treatment. Elsewhere they were considered non-syphilitic.

Both in 1931 and 1933 the blood of all three was examined at reliable laboratories and pronounced to have a negative Wassermann reaction. Night blindness was not a feature of the disorder, but the father noted dullness and mental apathy, especially in the case of the eldest boy.

Case I.—R.M., aged 14 years, a lanky boy for his age with a hatchet head and a dull apathetic expression, at first sight gave the impression of an oxycephalic defect, but on closer inspection this was obviously not so. The head was remarkable for its length and narrowness. There was undoubted mental deficiency, the patient was roused to attention with difficulty, and responded slowly and in a dull listless way to interrogation. The photographs and measurements appended give a better idea of the head than is conveyed by a written description; this is true, also, of the other members of the family.

Right and left eye vision = 6/60, not improved with lenses. Corneae and pupil reflexes normal.

Right eye.—Refractive media clear. Fundus examination revealed a diffuse central retinitis, the whole macular region showing an ill-defined tarnished brass appearance. The fovea is of a smoky or dull chestnut colour according to the angle of view. Around the macular area is a fine pale mottling, some of the spots are larger (0·25 disc diameter) and irregularly dentate, others rounded. The area of mottling extends for about 3 disc diameters temporal-wards of the macula. In places this change appears to be distributed along the vessels, but the mottling is deep to the capillary twigs. In the midperiphery and periphery there is no mottling, but towards the ora there are a few dark bluish patches. The disc is somewhat yellowish and pallid, but the vessels are not narrowed.

Left eye.—Very similar, but the change more marked. The fovea is of a dull chestnut colour surrounded by a paler dusky macula with a metallic sheen. The mottling is more irregular. A few spots are as large as half D. D., pale towards the centre and bluish at the margins; some are more opaque. The bulk of the change is inside a circle of 3 D. D. from the fovea, but there are a few bluish areas as in the other eye towards the ora. The vessels are not narrowed and do not suggest a tapeto-retinal type of degeneration.

Case II.—Wi., aged 12 years, was not so mentally dull nor so dolichocephalic as his elder brother.

Right and left eye vision = 6/60, not improved with lenses.

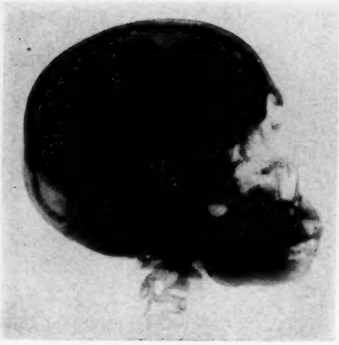
Corneae of average size, pupil reflexes normal, no opacities in the media.

Fundus examination:—*Right eye.*—No foveal reflex, the macular area has the appearance of beaten brass. There is an

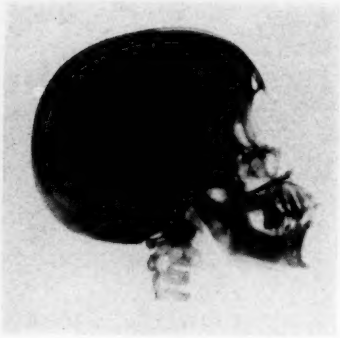
THE DAUGHTER, MOTHER AND FATHER

THE THREE BOYS, FRONT VIEW

THE THREE BOYS, LATERAL VIEW



THE FATHER

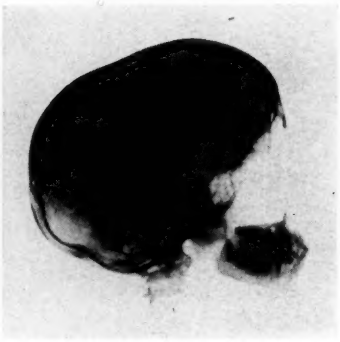


THE MOTHER

THE DAUGHTER

ELDEST SON

SECOND SON



YOUNGEST SON

indefinite mottling surrounding the macular area as far as the equator. It is very ill-defined, but gives a general impression of small round and larger irregular areas, some visible on account of their pale shade, others on account of their darkness, a faint mosaic or marbling effect. The distribution seems to have some relation to the vessels. The disc is of a somewhat yellowish colour, but definitely not atrophic. The vessels may be regarded as normal.

Left eye.—Fovea and macula same as in the right and also the mottling. There is definitely no pigment migration to be seen in connection with the mottled areas near the vessels, nor are there any changes in the vessels or discs to suggest a tapeto-retinal group disorder. As compared with the elder boy, the retinal change extends further towards the equator, without the bluish thinned areas near the ora.

Case III.—We., aged 11 years. Right and left eye vision = 6/60, not improved with lenses. Corneae normal, pupil reactions normal, media clear.

Fundus examination:—*Right eye.*—Fovea of a maroon colour with a reflex present, quite an ordinary fovea for a deeply pigmented eye in a South Indian youth. The macular area is definitely smoky on direct view, with a marked brassy metallic sheen on lateral illumination. In the perimacular region there is a fine mottling much finer than in the other two boys, hardly discrete. It extends about three disc diameters to the nasal side of the disc and to a corresponding extent temporal-wards, up and down. There is no abnormality of the vessels and the disc is within normal limits.

Left eye.—Similar except that around the deep chestnut coloured fovea there is an area of paler smoky chestnut encircled by a ring of a deeper smoky tint. In this boy the mottling does not extend as far forwards as in the second boy. The fundus details in all three cases were indefinite and difficult to picture in words. The true nature of such appearances in isolated cases, without the support of a familial distribution, might readily be missed, even with an associated mental deterioration or anatomical peculiarity. In this respect the familial macular degenerations as a group differ from the tapeto-retinal degenerations since the latter can nearly always be recognized ophthalmoscopically, even in the non-pigmented and more centrally distributed types, by the disc and vessel changes. Dr. Koman Nayar agrees with me that similar central appearances are familiar to him, as occasional findings in the dark room which could not always be accounted for except by assuming a degenerative process.

Two years ago (1931) each of the two elder boys received 20 sulpharsenol injections without any improvement to the sight (and

apparently without any definite damage, as the vision remained much the same after the course was finished).

The youngest boy, when examined by an eye doctor at the age of eight years, was said to have had normal vision. He still had good vision when the others were treated, nor did he develop poor vision till within the past year. Apparently in the case of all three there was not any defect in vision remarked on by parents or teachers till after the age of eight years. The previous family history was negative; the father, an intelligent man, said that he did not know of any relatives with bad sight on either side of the family, but it is quite likely that his knowledge of the maternal side was scanty. As a matter of routine the blood was examined here and all three boys and the father gave a negative Wassermann test.

The chief features of interest in this group of retinal defectives were: the reported escape of the girl (as yet, however, only seven years of age), and the associated progressive mental deterioration and dolichocephaly. In August, 1934, I had another opportunity of examining the whole family. As the father said on the occasion of the previous visit, the girl (now aged eight years) had nothing wrong with the vision, nor had the mother. The eye grounds of father, mother and girl were within normal limits. The girl, however, showed a concentric depression of the fields the outline lying between the 10° and 20° circles with a 3 mm. white object at 2 metres. (The mother's fields were much fuller extending beyond the 20° circle with a 2 mm. white object at 2 metres.) They showed two peaks at axes 45 and 135 in the inferior quadrant, the peak in the left inferior temporal quadrant being symmetrical with that in the right inferior temporal quadrant and reaching to the 40° circle in the form of a blunt cone. The inferior nasal peaks were similar, but only reached the 35° circle. The girl did not appear

AGE	SEX	Glabello-occipital length	Greatest breadth	Cephalic index	Minimum frontal diameter	Maximum frontal diameter	Inter-goinal width	Vertical height	Vertical index
48	Male -	191	152	80	124	142	99	142	74
43	Female -	172	130	76	101	118	87	134	78
15	Male -	214	133	62	107	122	95	130	61
13	Male -	193	127	66	99	115	78	126	65
12	Male -	183	141	77	104	128	84	132	72
8	Female -	175	137	78	100	118	78	129	74

Part of the table of anthropometric measurements supplied by Dr. Gravely and Mr. Raghavan of the Madras Museum in August, 1934.

to have a narrow elongated skull and the father seemed to be a square-headed individual, but the head of the mother was obviously of the long, narrow type. The actual conditions are shown in the reduced X-ray positives and in the anthropometric figures. The girl's measurements are not very different from those of the youngest boy. The girl is to report next year for further examination. The photographs and X-rays prints were kindly prepared for us by Captain Barnard and Dr. Pillai of the Barnard Institute of Radiology, Madras. Dr. Gravely of the Madras Museum has furnished me with the anthropometric measurements, and Drs. Vencatarangam Naidu and Vythinatha Iyer assisted in the collection of details necessary for this report.

RISING FRONT BIFOCALS

BY

F. A. WILLIAMSON-NOBLE

LONDON

THE ordinary form of bifocal glass possesses two disadvantages:—

1. That reading matter has to be held well below the horizontal plane in order to be clearly visible.

2. That the wearer is handicapped in going down steps and stairs, owing to the blurring and apparent displacement produced by looking at them through the reading portion of the glasses.

It occurred to me that these disadvantages might be overcome if an arrangement were provided by which the glasses could be lifted some 7 to 8 mm. above their ordinary position for then (1) the wearer could look almost straight ahead and yet be seeing through the reading portion of his glass, and (2) a space would be left below the glasses through which he could look down at steps and stairs and see them without the apparent displacement produced by looking obliquely through his presbyopic correction.

Various devices were tried and the most satisfactory and durable was found to be an adaptation of the "scholar's frame" type of bridge. This, as will be seen in Fig. 1, is attached to the spectacle frame by two sleeves in which it can slide up and down. The vertical members of the "scholar's bridge" are provided with a small nick which locks them in position when the glasses are in the high position. In actual practice though, the friction of the sleeves is sufficient to retain the spectacles in any desired position. With the glasses in the low position, they are indistinguishable in appearance from an ordinary pair, though when they are raised, the double bridge is, of course, apparent.

A second type of spectacle was made which rested on the bridge

of the nose (Fig. 2), the two different heights being obtained by revolving the bridge on a decentred axle. This also proved satisfactory, but the conspicuously thick nose piece is, perhaps, a disadvantage.

I am indebted to Messrs. Theodore Hamblin for their kindness and skill in making these spectacles, and for the illustrations of them.

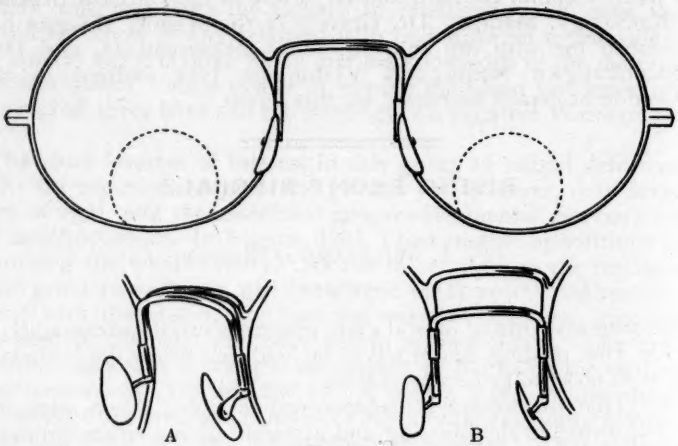


FIG. 1.

Scholar's frame fitted with "rising front."
A. Frame in normal position. B. Frame raised, by depressing back bridge.

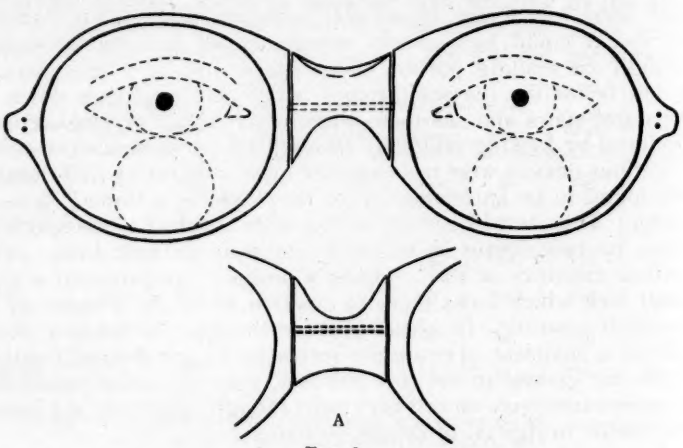


FIG. 2.

Tortoiseshell frame with "rising front."
A. Frame raised by rotating nose piece mounted on decentered axle.

ANNOTATION

Blindness in India

An interesting survey of Blindness in India by Sukumar Bagghi is contributed to the December, 1934, number of the *Calcutta Medical Journal*. His figures are taken from the 1931 census report. The population of India in that year was computed at 352,837,778, of whom 601,370 were blind. The definition of blindness on which these figures are based was "inability to count fingers of a hand held up at a distance of one yard." Only those blind of both eyes were included in these statistics.

The author's first table gives the proportion of blind to the entire population and literacy; the blind being taken as per 100,000 of population and the literates as per 1,000. In this table, Burma, with the largest number of literates (*sic*) (368 per mille) has 2·5 times more blind than Bengal, where the number of literates is a third that of Burma. Travancore, with a high proportion of literates, has a low proportion of blindness (63 per 100,000). The author is of opinion "that illiteracy has contributed handsomely to this large quota of blindness."

The second table gives the relation of sex and age to blindness. Up to the age of 35 years the number of blind females is slightly lower than that of blind males; but, after the age of 35 years, the number of female blind is higher than the males. The author says: "Up to the age of 35 years both males and females suffer equally from eye diseases and have an almost equal chance of blindness, but the male has to do more arduous work and has the greater chance of blindness from injury. After 35 years the susceptibility to eye disease is equal in both sexes, but whereas the males have recourse to treatment by going to hospitals or doctors, the females spend most of their time in the smoky atmosphere of their houses, because of their innate shyness and ignorance; do not seek medical aid, and thereby run an increasing risk of blindness.

The exact climatic conditions conducing to the causation of blindness are as yet undetermined, but it is found that the figures of blindness on the whole are heavier in the drier, dustier and more sandy parts of India.

The second part of the author's paper deals with statistics he took in the year 1932 while working at the Eye Infirmary Medical College, Calcutta. He collected 3,330 cases, of which 2,203 were males and 1,127 females. Of these, blindness was of both eyes in 1,034 cases and of one eye in 2,206 cases.

The Calcutta Blind School at Behala during the same year yielded 52 blind males and 22 females in the total of 74 inmates.

An elaborate table gives the causes of blindness in India. These are contrasted with similar tables prepared by Trousseau, in 1892, and by Magnus in 1870.

In the author's series senile cataract stands far and away supreme as the cause of blindness in India; next come injury, trachoma, corneal leucomata, keratomalacia, glaucoma, cyclitis and iritis, anterior staphyloma, corneal ulcer, optic atrophy, congenital cataract and small pox, in that order.

The European authorities, of many years ago, gave optic atrophy and purulent ophthalmia as the principal causes of blindness. Bagghi does not wish to compare his series with those of European authors too seriously as preventive medicine has made such great strides in the past half century. His figures show that purulent ophthalmia in India accounts for only 1·26 per cent. of blindness as against 16·16 per cent. (Trousseau), and 11·78 per cent. (Magnus.)

One of his cases was a pterygium in a Hindu woman, aged 39 years, who preferred blindness to simple operative interference.

ABSTRACTS

MISCELLANEOUS

(1) **Schieck, F. (Würzburg).—Autogenous blood injection into the anterior chamber in cases of tuberculosis of the anterior segment of the eye. (Die Ergebnisse der Eigenblutinjektion in die vordere Kammer der Tuberkulose des vordern Bulbusabschnittes).** *Klin. Monatsbl. f. Augenheilk.*, Vol. XC, p. 1, 1933.

(1) **Schieck** reports on 19 cases of anterior segment tuberculosis treated by replacement of the aqueous by autoserum. No deleterious effects were noted even when the reaction was severe. In one case and also in two cases of sympathetic ophthalmitis no good was achieved; in all the others there was rapid and surprising improvement after one or more injections. Increase of tension was not noted in any case even when the blood was long in being absorbed. In injecting blood from the patient's arm into the emptied anterior chamber, a quantity enough to cover the iris and pupil

should be used. The patient should not lie down, but remain sitting in a chair so that the blood should sink to the bottom of the chamber as soon as possible.

ARNOLD SORSBY.

(2) **Custodis, E. (Dusseldorf).—The pathology and treatment of cysts of the iris and anterior chamber. (Beitrag zur Pathologie und Therapie der Iris—und Iriskammer-Zysten).** *Klin. Monatsbl. f. Augenheilk.*, Vol. XC, p. 361, 1933.

(2) **Custodis** reports a case of traumatic epithelial cyst formation in the anterior chamber. Repeated operative attempts were unsuccessful, and ultimately X-ray was tried with a satisfactory result. The literature on the subject is reviewed and stress is laid upon the delayed action in some cases, favourable effects first becoming apparent after some months.

ARNOLD SORSBY.

(3) **Pagès, R. (Morocco).—Iridocyclitis in the course of amoebic dysentery. (Les iridocyclitis au cours de la dysenterie amoebienne).** *Folia Ophthal. Orientalia*, Vol. I, Fasc. 3, p. 305, 1933.

(3) **Pagès** describes a case of amoebic dysentery in which every onset of this disease was followed by iridocyclitis with hypopyon. All other causes for the iridocyclitis could be excluded. After thorough treatment with emetin and yatrene 105 the attacks of dysentery and iridocyclitis did not recur.

Pagès suggests that there are two ocular syndromes associated with dysentery:—(1) The conjunctivo-arthro-synovial syndrome; (2) amoebic dysentery-iridocyclitis syndrome. In the author's view the former is probably of toxic origin and the latter metastatic.

H. B. STALLARD.

(4) **Miklos, A. (Debrecen).—The growth of bacteria in media containing lens matter. (Bakterienzüchtung in linsenhaltigen Nährboden).** *Klin. Monatsbl. f. Augenheilk.*, Vol. LXXXIX, p. 481, 1932.

(4) **Miklos** follows up the work of earlier observers who showed that the lens is a good culture medium. Employing the more common conjunctival organisms and the more common media he gives comparative values with both human and bovine lens matter as the culture medium. Lens emulsion was found to be the best medium, bovine lens being better than human. Sodium chloride solutions and sterile water checked the growth of organisms. Aqueous itself does not give luxurious growths, but inactivated aqueous does; when lens matter is present in the aqueous, the growth of organisms is not checked, even if the aqueous has not

been inactivated. The best culture medium was inactivated aqueous with human lens matter. Lens in blood serum is a good medium, especially for pneumococci. The significance of these findings for clinical cases with lens débris in the anterior chamber is discussed.

ARNOLD SORSBY.

BOOK NOTICES

Annual Report of the Department of Health of Palestine, 1933 Printing Office, Jerusalem. Price, with postage, 130 mils.

Palestine has the distinction of being the country where there is a greater percentage of blindness than any other in the world. This is the result of seasonal epidemics of acute conjunctivitis caused by the action of well-known bacterial organisms. Under certain conditions the inevitable background of trachoma is an adjuvant.

Palestine is richly provided with means for the relief of ocular disease as compared with other countries, though still insufficiently to cope with the vast amount which exists.

Considerable additional credits have been granted in view of the high incidence of blindness in Southern Palestine which the census of 1931 revealed.

The lines of expansion recommended by the Consulting Ophthalmic Surgeon to the Government, Dr. W. E. Thompson, were similar to those adopted for some years by the Department of Health, but with the addition of village clinics, conducted by trained hospital attendants (tamurgis), and supervised by the Medical Officers of central stationary clinics.

These village clinics have been most successful. Not only did the tamurgis see and give first aid to a very large number of patients with early acute conjunctivitis, but they also visited a selected number of villages in the vicinity and collected and treated other patients who subsequently attended at their village clinics. The frequent visits of the Medical Officer of the Central Clinic to all the village clinics permitted him to see and prescribe treatment to be carried out by the tamurgi for all new cases, or to transfer cases to his own Central Clinic.

Undoubtedly the expansion of the ophthalmic work resulted in curtailment of several epidemics of acute conjunctivitis and in the early treatment and cure of a large number of cases which would otherwise have developed impairment of vision or blindness. Even under treatment, 6·4 per cent. of the cases developed corneal ulcers.

However, this is better than in another district where there were no first aid clinics, for here ulceration of the cornea developed in 16·6 per cent. of the cases.

A mobile ophthalmic unit was ordered during the year. It will consist of a motor-lorry with specially designed interior and suspended tent attachments for doctor's and nurses' clinics, together with a trailer for the accommodation of two nurses. The inside of the lorry will provide storage for equipment of the clinic and for the office and sleeping accommodation of the doctor.

The Director of Health, Colonel Heron, in the more general sections of the Report, remarks on the shortage of water. Many of the villages depend entirely on rain water cisterns, and the majority were not filled during the preceding winter. Most of the springs in the hill country dried up in the early summer. It was common for villagers to travel from three to nine miles each way for water; under these conditions acute ophthalmias ran rife.

Strabismus. By A. CANTONNET and J. FILLIOZAT, with the collaboration of G. FOMBEURE, translated from the French by the late Dr. Max Coque, B.Sc. Pp. 379, with 83 illustrations. First edition. London: M. Wiseman & Co. 1934.

Much trouble has obviously been taken in the preparation of this book on squint. The subject matter is divided into three sections.

Part I deals with the physiology of vision in which the authors assemble old theories and add their own views to them. They introduce such instruments as Cantonnet's Test for Binocular Vision, Remy's Separator and Diploscope, and others. As diagnostic instruments, these are more or less comparable to Maddox Wing and Rod Test, Bishop Harman's Binocular Test, and Worth's Amblyoscope; as training instruments, they supply a variation and supplement to the instruments in everyday use.

Part II deals with the pathology of binocular vision and attempts to correlate the cases of binocular instability with cases of manifest strabismus, and later deals with the relationship of the squinting eye to the directing eye.

Part III sets forth the considerations and methods of the re-education of squinters. The authors find that 70 per cent. of cases react to orthoptic treatment alone without surgical measures and that it is possible to deal with cases up to 35 or 40 years of age. Their method is directed to the usual aim of the development of the fusion faculty and to the breaking down of the suppression in the affected eye.

Unfortunately a translation adds difficulty to the reading and the text tends to be complicated by unnecessary similes and reiterations. The authors, however, bring much enthusiasm to their subject.

A Handbook of Ophthalmology. By HUMPHREY NEAME and F. A. WILLIAMSON-NOBLE. Second edition. Pp. 323. Illustrations. Twelve coloured plates, containing 46 coloured illustrations, and 147 text figures. London: J. and A. Churchill. 1935. Price, 12/6.

This book is written for undergraduate students and general practitioners and presents to them in a succinct and lucid manner the essentials of ophthalmology. It contains many points of practical interest and value. Those diseases which form the bulk of out-patient practice and the commoner ocular conditions found among medical in-patients are described, rarities receiving only brief mention.

The technique of the usual methods of examination is carefully described. The subject matter is attractively written and reads easily. The illustrations, many of which are coloured plates, are good. It is remarkable that so many of these have been incorporated in a text-book at such a modest price.

Reference is made to recent work in the surgical treatment of retinal detachment by the various diathermy methods and to the effect of an "H" substance in the experimental production of acute glaucoma. Greeves' operation for ptosis has received note, and tuberculin and T. A. B. as a method of modified protein-shock therapy are discussed. The effects and value of local and general ultra-violet radiation are mentioned in several sections.

There is an additional chapter on tropical ophthalmology written by Major H. Williamson, I.M.S. This is of considerable interest and enhances the value of work, particularly for those practitioners who may find their professional field of work in tropical countries.

The index is approximately double in size compared with that of the first edition, and for this arduous task the authors express their thanks to Mr. E. F. King. The book is well produced and is an admirable handbook for the large section of the profession to whom it is addressed.

The Practice of Refraction. By SIR STEWART DUKE-ELDER. Second edition. Pp. 374, 180 illustrations. London: J. and A. Churchill. 1935. Price, 12/6.

This book presents the practice of refraction work in a clear and concise manner. It will be particularly appreciated by the post-graduate student beginning his ophthalmological studies as it is devoid of lengthy dissertations on higher mathematics and physics and is confined in the main to points of practical value.

Recent work on the incidence of refractive errors, the aetiology of myopia, the prescription of contact glasses and orthoptic training are among the topics of current interest which the author has discussed.

The book is essentially of a clinical character and theoretical matters are dealt with only to make their application to practical problems understandable.

The author submits this work as a guide to the practitioner undertaking refraction work, but comments that "the art of refraction cannot in any sense be learned by reading, but only by assiduous and painstaking practice in the clinic of a hospital, where large numbers of cases of all kinds are available, where the findings can be supervised and corroborated, and where long practice makes the interpretation of results instantaneous."

NOTES

Death

WE much regret to record the death of Dr. James Collier on February 9. For many years he was Physician to the Royal Eye Hospital, as well as to St. George's Hospital and the National Hospital, Queen Square.

The son of a medical man and the brother of the equally gifted Horace Collier, whose early retirement through ill-health was a genuine tragedy, James Collier was educated at St. Mary's Hospital and the University of London. He had a brilliant career as a student, winning scholarships and medals and early showed the bent of his mind by becoming House Physician at Queen Square. His services at St. George's Hospital were so much appreciated by his colleagues that he was elected Emeritus Lecturer on neurology in the medical school when he became Consulting Physician to the hospital after 20 years' service on the senior staff.

The writer had the good fortune to be present at Collier's first out-patient clinic after his election to St. George's and to have been his House Physician; he would like to record his admiration for Collier's kindness, single-mindedness and vivid personality.

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International Ophthalmological Council

THE International Association for the Prevention of Blindness, The International Organization in the Struggle against Trachoma. All these Councils are meeting at the Royal Society of Medicine during the forthcoming congress of the Ophthalmological Society in April.

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Ophthalmological Society of the United Kingdom. Annual Congress

THE subject for discussion is "Diseases of the blood and their ophthalmological complications," to be opened by Sir Arnold Lawson, Dr. H. L. Tidy, Prof. E. C. Dodds and Dr. P. N. Panton. In

connexion with the congress there will be meetings of the International Council of Ophthalmology, the International Association for the Prevention of Blindness, and the International Trachoma Association.

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Ophthalmological Society of Egypt

THE Annual Meeting of the Ophthalmological Society of Egypt will take place at the Memorial Ophthalmic Laboratory, Giza, on March 22, 1935.

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The Gifford Edmonds Prize, 1934

THE Prize has been awarded to Mr. T. a'T. Travers, of Melbourne. The essay submitted by Miss M. A. Pugh was of high distinction and deserved honourable mention.

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International Association for the Prevention of Blindness. Reception

A RECEPTION by the Government is to be given to International Delegates and members of Ophthalmological Societies, on Friday, April 5, at 10 a.m., at the London Museum, St. James'. Will those wishing to be present please communicate with Mr. R. C. Davenport, 39, Devonshire Place, W.1?

* * * *

Pension for a Blind Priest

ADAM COXELOT, priest, became Rector of Lopham, co. Norf., in 1404. In 1423, Adam having grown old and blind so that he could not serve this cure, resigned; and the Bishop of Norwich, at the institution of his successor, obliged the latter to pay Adam a pension of £10 per ann. during his life.

This is one of the earliest instances recorded of the pensioning of a parson when no longer able, through bodily defects, to do his duty.

FUTURE ARRANGEMENTS

1935

March 8.—Section of Ophthalmology, Royal Society of Medicine (Clinical Meeting).

March 15.—North of England Ophthalmological Society, at Liverpool.

April 4–6.—Ophthalmological Society of the United Kingdom (Annual Congress).

April 5.—Midland Ophthalmological Society, at Nottingham Eye Infirmary.

April 12.—North of England Ophthalmological Society, at Sheffield.

May 31. – Midland Ophthalmological Society, at Bath Eye Infirmary (joint meeting with South-Western Ophthalmological Society).

June 14.—Section of Ophthalmology, Royal Society of Medicine (Annual Meeting).

July 4, 5 and 6.—Oxford Ophthalmological Congress, at Oxford.

July 29—*August* 2.—Second International Neurological Congress, in London.

October 1.—Midland Ophthalmological Society, at Birmingham Eye Hospital.

December 3.—Midland Ophthalmological Society, at Birmingham Eye Hospital.

CONTEMPORARY OPHTHALMIC LITERATURE

American Journal of Ophthalmology. *January, 1935.*

WHEELER. Advancement of the superior oblique and inferior oblique ocular muscles.

REESE. The occurrence of ciliary processes on the iris.

JULIANELLE and HARRISON. Studies on the infectivity of trachoma.

DAVIS. A modified recession operation for strabismus.

BAILEY. The oculo-cardiac reflex.

MCLAURIN. An operation for glaucoma.

SHAPIRA. Glaucoma capsulare.

HORNER. Sutures for lid control in cataract operations.

MCKEE. Inclusion blennorrhea.

LAMB. Hyperplasia of the covering epithelium of the tarsal conjunctiva in trachoma.

O'CONNOR and PIERCE. Eyesocket reconstruction necessitated by extra-ocular myositis associated with thyroid disease.

Annales d'Oculistique. *January, 1935.*

REDSLOB. Is primary glaucoma an inflammatory affection?

GOLDMANN. The development of glass-makers' cataract.

MORAX and ROUSSEAU. A case of orbital neoplasm difficult to diagnose.

Archives d'Ophtalmologie. *January, 1935.*

DUVERGER. The immediate treatment of perforating wounds of the globe.

EKERS and LAPIERRE. Treatment of angiomata of the eyelids by sclerosing injections.

RABINOVITCH and VENGRJENOVSKY. A case of progressive myasthenia with participation of the unstriped muscles of the eye.

VIALLEFONT. Ocular manifestations of xeroderma pigmentosum.

Klinische Monatsblätter für Augenheilkunde. *January, 1935.*

VON SZILY. Experiment as to transmissibility with trachoma material. A further contribution to the knowledge of the exciting cause of the follicle formation.

OLOFF. Congenital trichromic blue anomaly.

HARTUNG. Investigations on colour asthenopia.

KOKOTT. The split linear formation in the sclera. Demonstration of the functional structure of the sclera.

ENGELKING. Clinical picture of intra-scleral nerve loops.
VANNAS. Tuberculin allergy and ocular phlyctenulosis.
KUKAN. A contribution to the question of ocular changes caused by lymphocytomatosis.
NOWKIRISCHKY. A rare kind of stone splinter injury of the eye.
FRYKHOLM. Familial corneal degeneration, inherited through six generations, clinical demonstrations with 13 members of the three last.
HESSE. A simple procedure, demonstration of simulation or sublimation of asthenopia.

Annali di Ottalmologia e Clinica Oculistica. *November, 1934.*

CORRADO. The aetiological problem of hereditary familial atrophy of the optic nerve. (Leber's disease.)
GIANNINI. The influence of some pharmaco-dynamic substance, introduced endonasally, on the retinal arterial circulation.
VILLANI. Biomicroscopy of the diabetic eye.

December, 1934.

CORRADO. Clinical and histo-pathological contribution to retro-retinal haemorrhage with particular regard to the differential diagnosis of choroidal tumours.
GIANNINI. Alterations of the pigment cells of the retina in highly myopic eyes and their importance in the pathogenesis of retinal detachment.
BUCALOSSI Adhesive choroido-retinitis from superficial diathermy coagulation and from chemical cauterization of the sclera.
GIANNINI. The influence of circulatory disturbances on the pathogenesis of the functional and anatomical alterations of the optic nerve and of the retina in quinine poisoning.

Bollettino d'Oculistica. *December, 1934.*

BIETTI. Bilateral malformation of the palpebral border of the conjunctiva and of the cornea from an aspect not yet described.
GUERRIERI. Contribution to the knowledge of the phenomena of permeability and diffusion of the cornea.
BALCET. The action of hydrochlorate of methyloctenilamine on the eye.
GALEAZZI. Osteogenesis imperfecta and blue sclerotics.
SMALTINO. Ocular complications in spondylosis.
PALMIERI. Experimental research on the pathogenetic mechanism of congenital lens opacities.

Archivos de Oftalmologia Hispano-Americanos.

BALBUENA. Variations in the connective tissue from silver impregnation.

Revista Oto-Neuro-Oftalmologica e Radio-Neuro Chirurgica.

November-December, 1934.

FILIPPI-GARBARDI Further clinical contribution to the knowlege of ocular syndromes of alterations of the internal carotid.
FIAMBERTI. Retinal spasm, prodrome of the onset of mania.
VENCO. The ocular neuroparalytic syndrome in the surgical lesions of the trigeminal nerve. Degenerative alterations of the cornea following the injection of alcohol into the Gasserian ganglion.
FILIPPI-GARBARDI. The correlation of the naso-ocular reflexes.
BOSSALINO. Congenital monocular absence of lateral movements associated with paresis of the superior rectus muscle of the opposite side with agenesis of the frontal sinus.
VISALLI. Paralytic lagophthalmos not enough to produce corneal ulceration.